Asilomar Conference
"The Hydrogen Transition"
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FreedomCAR and Fuel Initiative

H_2

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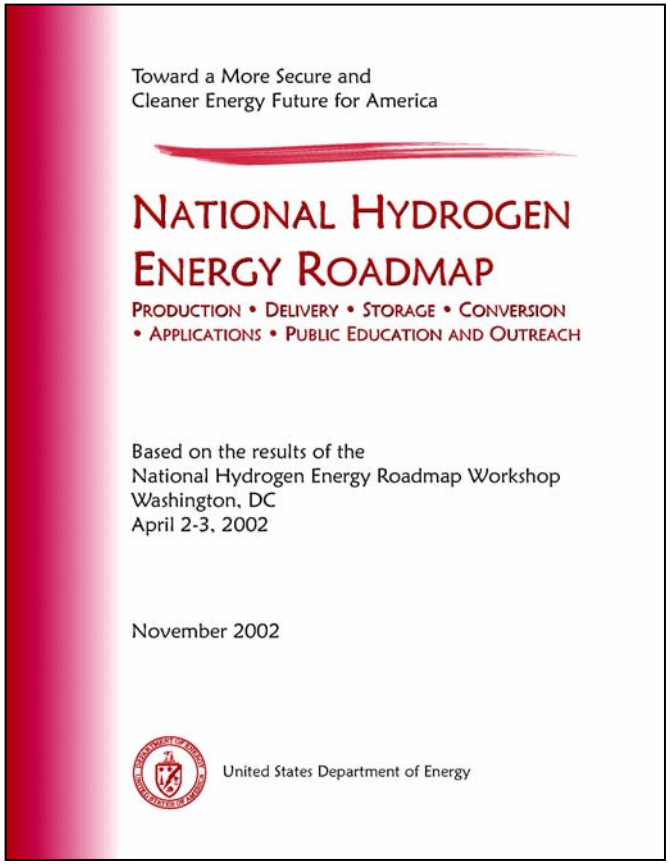
Barriers to Hydrogen Economy

Technology Barriers

1. Hydrogen storage systems for vehicles are inadequate to meet customer driving range expectations without intrusion into vehicle cargo or passenger space.
2. Hydrogen is currently three to four times as expensive as gasoline.
3. Fuel cells are ten times more expensive than internal combustion engines and do not maintain performance over the full useful life of the vehicle.

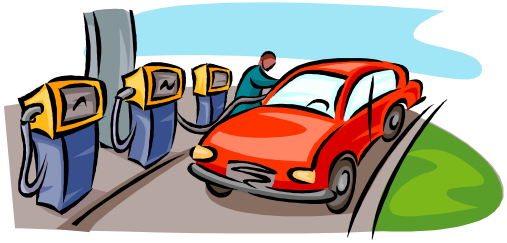
Economic and Institutional Barriers

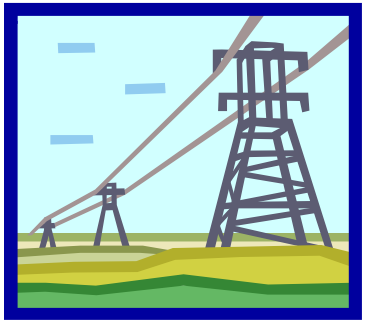
1. Investment risk of developing a hydrogen delivery infrastructure is too great, given technology status and current demand.
2. Uniform model codes and standards to ensure safety, insurability, and fair global competition are lacking.
3. Local code officials, policy makers, and the general public lack education regarding hydrogen safety and benefits.



Approach to Overcoming Barriers

- Establish time-phased technical targets that measure progress against barriers
- Targets from R,D&D Plans used to establish performance-based milestones and deliverables in implementation mechanisms (Lab Annual Operating Plans, Industry Cooperative Agreements, etc) established with National Labs, contractors and universities
- DOE role ramps down as targets are met in “systems context” under real operating conditions (Fuel Cell Report to Congress lays out timelines for hydrogen vehicles and infrastructure)





Hydrogen vehicle and infrastructure “learning” demonstrations - Current DOE Solicitation, $150 M over 5 years

FutureGen: Emissions-free coal plant to generate hydrogen and electricity with carbon capture/sequestration, solicitation $1 billion over 10 years

Engaging the Nation's Brightest Minds

THE NATIONAL ACADEMIES
Advisers to the Nation on Science, Engineering, and Medicine

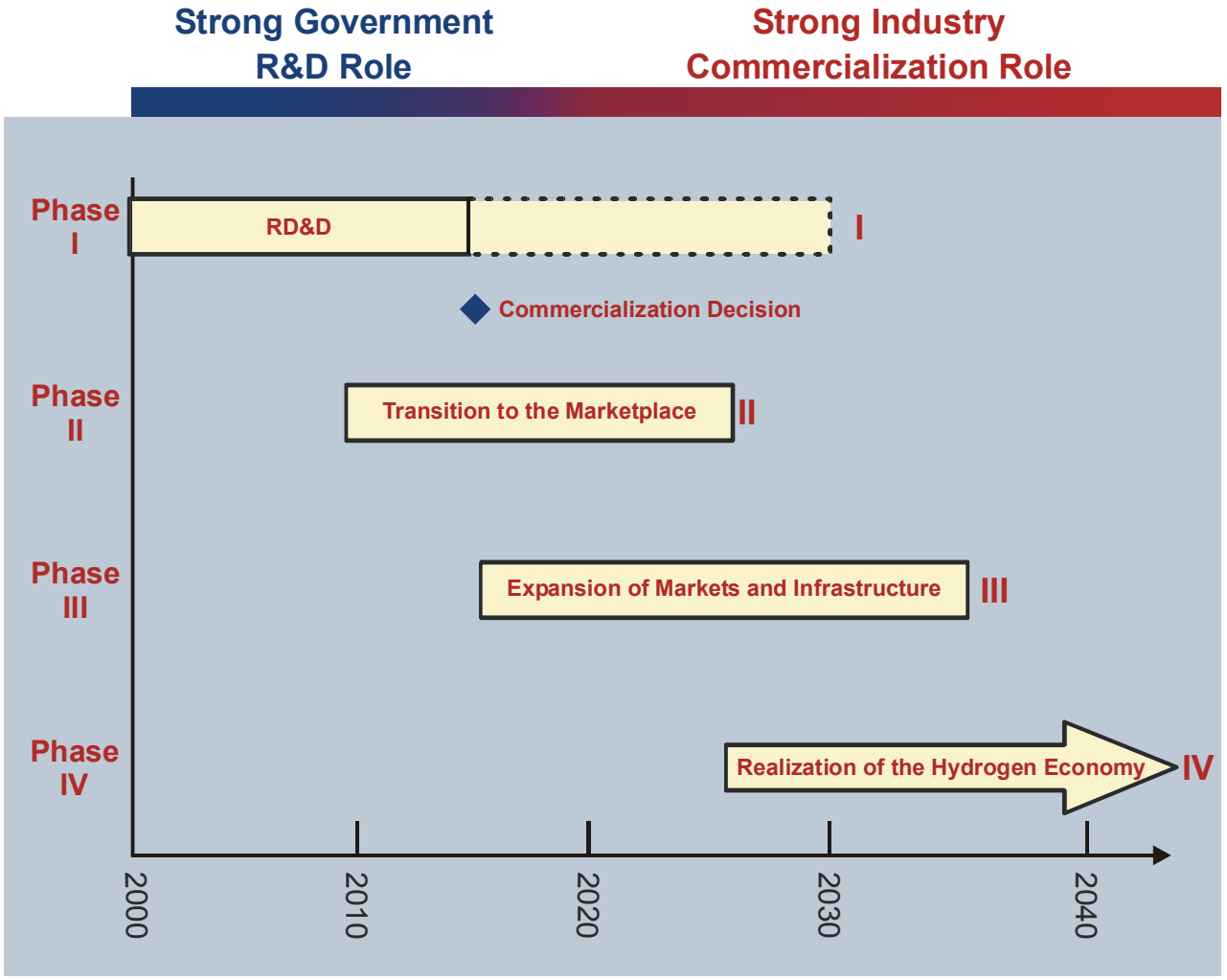
- Helping to develop the hydrogen production feedstock strategy by prioritizing research areas
- Evaluating Hydrogen Fuel Cells R, D & D Plan
- Bringing together experts from diversity of private sector fields and academia

Creating a Systems Integrations Plan to analyze all models & pathways and appropriately integrate individual efforts with overall objectives at the macro-system level.

Hydrogen Storage "Grand Challenge"

- Building on Storage "Think Tank" meetings, involving 4 Nobel Laureates and 7 award-winning scientists (ACS, APS, and NSF awards; Presidential Young Investigators)
- Creating integrated teams of technology experts and researchers in virtual research center

Timeline



Transitional Phases

I. Technology Development Phase

II. Initial Market Penetration Phase

III. Infrastructure Investment Phase

IV. Fully Developed Market and Infrastructure Phase

Approach to Policy

Predominate Policy now is R&D, with background research for future safety regulations and codes and standards

- Too early for large scale demonstrations
- Will lower costs through materials R&D and improving performance, not through premature volume production
- Early adopter conditions
  - Close to meeting customer requirements
  - Business case near establishment point
- Role for “learning” demonstrations”

Evaluating the Technology Pathway

	2000 – 2004 **Phase 1** **Technical Feasibility**	2004 – 2009 **Phase 2** **Controlled Fleet Test and Evaluation**	2009 – 2015 **Phase 3** **Commercial Readiness Demonstrations**	2015 – **Commercialization Phase**
Vehicles Objective	Test FC vehicle performance and feasibility	Evaluate use of FC vehicles under real-world conditions	Demonstrate commercial viability of FC Fleet vehicles	Investment to establish manufacturing plants and sales/service
Infrastructure Objective Hydrogen Source	Demonstrate H_2 fueling station; Analyze fuel options Primarily trucked in liquid	Onsite generation from multiple feedstocks Renewable & fossil fuels	Sufficient stations to provide consumer convenience Most cost effective sources by region	Investment for Substantial number of all stations to be H_2 capable
Go/No-Go Decision Points	Proposed Decision Criteria-Phase 1: Hydrogen vehicles achieve 1000 hrs durability, $200/kW cost (projection based on 500,000 units production). R&D results project 2500 hrs durability, $125/kW, $3.00/gallon gasoline equivalent (untaxed)	Proposed Decision Criteria-Phase 2: Hydrogen vehicles achieve 2500 hrs durability, $125/kW cost (projection based on 500,000 units production) & hydrogen at $3.00/gallon. R&D results project 5000 hrs durability, $45/kW, $1.50-2.10/gallon gasoline equivalent (untaxed), and 120 g/mi greenhouse gases	Proposed Decision Criteria: Based on capability to achieve 5000 hrs durability, $45/kW cost (500,000 units), $1.50/gallon gasoline equivalent (untaxed), 120 g/mi greenhouse gases and other market factors. The decision to enter a commercialization phase will be made by industry	

R&D Continues Concurrently to address key cost and performance barriers

Learning Demonstrations Play a Role

- 3 Phases of Demonstrations

- 1. Technical Feasibility
- 2. Controlled Fleet Test and Evaluation
- 3. Commercial Readiness Demonstrations